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## EUROPEAN PATENT APPLICATION

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(72) Inventors:  
• Turner, Gary A.  
Three Rivers, Michigan 49093 (US)  
• Rodgers, Mark Edward  
Augusta, Michigan 49012 (US)

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(71) Applicant: DANA CORPORATION  
Toledo, OH 43697 (US)

(74) Representative:  
Cheyne, John Robert Alexander Mackenzie et al  
Haseltine Lake & Co.,  
Imperial House,  
15-19 Kingsway  
London WC2B 6UD (GB)

### (54) Differential with threaded bearing cup and locking mechanism

(57) A differential allowing relatively easy alignment and secure positioning of bearings is provided. The differential includes a differential carrier (12) and a differential case (20) disposed within the carrier. A bearing assembly (36) is located between the differential carrier and the differential case and allows the differential case to rotate within the differential carrier. The differential

carrier and a cup (76) of the bearing assembly having mating threads allowing relatively easy alignment of the bearing assembly within the differential. A deformable (40) member is attached to the bearing assembly cup and is deformed and inserted into a slot (100) in the differential carrier upon alignment of the bearing assembly to securely position the bearing assembly.

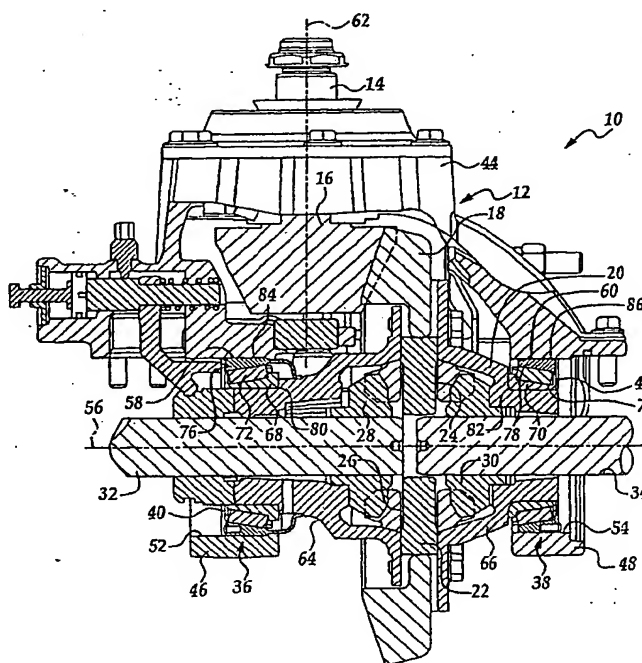


Figure 1

## Description

**BACKGROUND OF THE INVENTION****1. Field of the Invention**

[0001] This invention relates to vehicle differentials and, in particular, to a differential and method for assembling a differential that enables relatively easy alignment and secure positioning of bearings within the differential.

**2. Discussion of Related Art**

[0002] Differentials are provided on vehicles to divide power provided at two outputs. A wheel differential enables a pair of wheels on a common rotational axis to rotate at different speeds while the vehicle is turning. A conventional differential includes a differential carrier that receives a power transmission shaft having a pinion gear mounted at one end. The pinion gear is disposed within the differential and meshes with a ring gear that is coupled to, or integral with, a differential case. The case supports a plurality of bevel gears that transmit torque to a pair of axle half shafts that are in turn coupled to a corresponding pair of wheels.

[0003] The differential case is supported for rotation within the differential carrier by a pair of bearing assemblies. During assembly of the differential, each of the bearing assemblies must be properly aligned by moving the bearing assembly axially inward and outward along the axis of rotation. Conventional bearing assemblies are typically positioned and aligned within the differential carrier using threaded bearing adjusters that urge the bearing assemblies axially inward and outward. Bolts, clips, cotter pins or metal stampings are used to maintain the position of the bearing adjusters within the differential once a predetermined alignment position is reached. This configuration has a significant disadvantage. The bearing adjusters typically have a finite number of lugs (e.g., twelve to sixteen) projecting therefrom. The bolts, clips, cotter pin or stampings are inserted into one of the lugs or in between a pair of lugs to retain the bearing adjuster in place. As a result, the bearing adjuster, and therefore the bearing assemblies, can only assume certain angular and axial positions thereby limiting the ability to optimally align the bearing assemblies within the differential.

[0004] The inventors herein have recognized a need for a differential and method of assembling a differential that will minimize and/or eliminate one or more of the above-identified deficiencies.

**SUMMARY OF THE INVENTION**

[0005] The present invention provides a vehicle differential and a method for assembling a differential.

[0006] A differential in accordance with one aspect of the present invention includes a differential carrier dis-

posed about a first axis and a differential case disposed within the differential carrier. A bearing assembly is disposed about the first axis between the differential carrier and the differential case. The bearing assembly allows the differential case to rotate within the differential carrier. The differential carrier includes a first plurality of threads disposed on a radially inner surface. The bearing assembly includes a cup having a second plurality of threads disposed on a radially outer surface that are configured to engage the first plurality of threads.

[0007] A differential in accordance with a second aspect of the present invention also includes a differential carrier disposed about a first axis and a differential case disposed within the differential carrier. A bearing assembly is again disposed about the first axis between the differential carrier and the differential case to allow the differential case to rotate within the differential carrier. The differential further includes a deformable member coupled to a cup of the bearing assembly. At least a portion of the deformable member is deformed and inserted into a slot in the differential carrier upon alignment of the bearing assembly within the differential carrier.

[0008] A method of assembling a differential in accordance with the present invention may include the step of providing a differential carrier and a differential case disposed within the differential carrier wherein the differential carrier and the differential case are disposed about a first axis and the differential carrier has a first plurality of threads on a radially inner surface. The method may further include the step of inserting a bearing assembly between the differential carrier and the differential case wherein the bearing assembly includes a cup having a second plurality of threads disposed on a radially outer surface and configured to engage with the first plurality of threads on the differential carrier. The method further includes the step of rotating the bearing assembly until a predetermined alignment position is reached. The inventive method may also include the steps of affixing a deformable member to the cup of the bearing assembly, deforming at least a portion of the deformable member after reaching the predetermined alignment position, and inserting the at least a portion of the deformable member into a slot in the differential carrier.

[0009] A differential in accordance with the present invention is advantageous. The bearing assembly between the differential carrier and differential case may be rotated to align the bearing assembly and may assume an infinite number of angular positions and axial positions providing greater control of alignment than in conventional differentials. The deformable member provides a relatively inexpensive method of securing the position of the bearing assembly upon alignment of the bearing assembly within the differential.

[0010] These and other advantages of this invention will become apparent to one skilled in the art from the following detailed description and the accompanying drawings illustrating features of this invention by way of

example.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0011]

Figure 1 is a partial cross-sectional view of a differential in accordance with the present invention.

Figure 2 is perspective view of a bearing cup and deformable member of the differential of Figure 1.

Figure 3 is a cross-sectional view a bearing cup and deformable member of the differential of Figure 1.

Figure 4 is a perspective view illustrating engagement of a carrier and deformable member of the differential of Figure 1.

Figure 5 is a block diagram illustrating a method for assembling a differential in accordance with one embodiment of the present invention.

Figure 6 is a block diagram illustrating a method for assembling a differential in accordance with another embodiment of the present invention.

## **DETAILED DESCRIPTION OF ONE OR MORE EMBODIMENTS OF THE INVENTION**

[0012] Referring now to the drawings wherein like reference numerals are used to identify identical components in the various views, Figure 1 illustrates a differential 10 in accordance with the present invention. Differential 10 is provided for use in vehicles to enable a pair of wheels on a common rotational axis to rotate at different speeds. Differential 10 may include a differential carrier 12 that receives a power transmission shaft 14, a pinion gear 16, a ring gear 18, a differential case 20, a differential spider 22, a plurality of bevel gears 24, 26, 28, 30, and axle half shafts 32, 34. Differential 10 may also include bearing assemblies 36, 38 in accordance with one aspect of the present invention and may further include deformable members 40, 42 in accordance with another aspect of the present invention.

[0013] Carrier 12 houses, provides supports for, and maintains the relative position of, the other components of differential 10. Carrier 12 may be made from conventional metals and metal alloys such as steel and is conventional in the art. Carrier 12 may include several members coupled together using conventional fasteners (not shown). These members may include, but are not limited to, forward member 44 and bearing caps 46, 48. Members 44, 46, 48 of carrier 12 together define a pair of openings 52, 54 disposed about an axis 56 of rotation for axle half shafts 32, 34 and through which shafts 32, 34 extend. Carrier 12 also defines pluralities of threads 58, 60 on at least a portion of the radially inner surfaces of members 44, 46, 48 that define openings 52, 54.

[0014] Shaft 14 transfers torque from a drive shaft (not shown) to pinion gear 16 and is conventional in the art. Shaft 14 is disposed about an axis 62 of rotation that extends generally perpendicular to axis 56. Shaft 14 is

supported for rotation within member 44 of carrier 12 by a pair of bearing assemblies (only one of which is partially visible in Figure 1).

[0015] Pinion gear 16 transfers torque from shaft 14 to ring gear 18. Pinion gear 16 may be made from conventional metals and metal alloys and may comprise a hypoid gear. Gear 16 rotates about axis 62. Gear 16 is disposed about shaft 14 and may be integral therewith as shown in the illustrated embodiment or may be mounted thereto using a conventional spline connection or in other ways customary in the art.

[0016] Ring gear 18 is provided to transfer torque from pinion gear 16 to case 20 and is conventional in the art. Ring gear 18 may also be made from conventional metals and metal alloys and may also comprise a hypoid gear. Gear 18 is affixed to case 20 or may be integral therewith and is disposed about axis 56.

[0017] Case 20 is provided to house spider 22 and bevel gears 24, 26, 28, 30 and to transfer torque to bevel gears 24, 26, 28, 30. Case 20 is conventional in the art and may be made from conventional metals and metal alloys. Case 20 includes first and second members 64, 66 that are coupled together using fasteners such as bolts or in other ways customary in the art. Case 20 is disposed within carrier 12 and, in particular, within openings 52, 54 of carrier 12. Case 20 is also disposed about axis 56 and is supported for rotation about axis 56 relative to carrier 12 by bearing assemblies 36, 38.

[0018] Spider 22 provides a mounting arrangement for bevel gears 24, 26 and is conventional in the art. Spider 22 is coupled to case 20 for rotation therewith and supports at least two bevel gears 24, 26 that rotate with spider 22.

[0019] Bevel gears 24, 26, 28, 30 are provided to divide and transfer torque between axle half shafts 32, 34. Gears 24, 26, 28, 30 are conventional in the art and may be made from conventional metals and metal alloys. Gears 24, 26 are mounted on spider 22 for rotation with spider 22. Gears 28, 30 are mounted on axle half shafts 32, 34 for rotation with shafts 32, 34 and rotate in response to rotation of gears 24, 26.

[0020] Axle half shafts 32, 34 transfer torque to wheels (not shown) disposed on either side of differential 10. Shafts 32, 34 are conventional in the art and extend outwardly from differential case 20 and carrier 12 through openings 52, 54.

[0021] Bearing assemblies 36, 38 enable rotation of differential case 20 within carrier 12. Assemblies 36, 38 are disposed within openings 52, 54 of carrier 12 between case 20 and carrier 12 and are disposed about axis 56. Each of assemblies 36, 38 may include a cone 68, 70, bearing members 72, 74, and a bearing cup 76, 78, respectively.

[0022] Cones 68, 70 define a radially inner bearing race and are conventional in the art. Cones 68, 70 are supported on a radially outer surface of case 20 and abut shoulders 80, 82, respectively, formed in case 20.

[0023] Bearing members 72, 74 are disposed be-

tween cones 68, 70 and cups 76, 78, respectively. Members 72, 74 are also conventional in the art and may comprise tapered roller bearings.

[0024] Cups 76, 78 define a radially outer bearing race and are disposed about axis 56, cones 68, 70 and bearing members 72, 74. In accordance with the present invention, cup 76, 78 each define a plurality of threads 84, 86, respectively, on a radially outer surface. Threads 84, 86 are configured to engage corresponding threads 58, 60, on a radially inner surface of carrier 12 to allow movement of bearing assemblies 36, 38 within openings 52, 54 inward and outward along axis 56.

[0025] Referring now to Figures 2-3, deformable members 40, 42 secure the position of bearing assemblies 36, 38 once assemblies 36, 38 have attained a predetermined alignment position within differential 10. Although a single deformable member 40 is illustrated in Figures 2-3, it should be understood that members 40, 42 may be identical in construction and that the additional description of member 40 set forth herein may be equally applicable to member 42.

[0026] Each member 40, 42 may comprise a stamping made from sheet metal or a similar malleable material and is coupled to a corresponding cup 76, 78 of a corresponding bearing assembly 36, 38. Each member 40, 42 may be annular in shape and is disposed about axis 56 upon installation within differential 10 (as shown in Figure 1). Each member 40, 42 is generally L-shaped in cross-section and has two legs 88, 90.

[0027] Leg 88 extends radially relative to axis 56. Leg 88 defines a plurality of apertures 92 through which fasteners 94 may be used to couple leg 88, and therefore member 40, to a corresponding cup 76 of a corresponding bearing assembly 36. Apertures 92 may be equally angularly spaced about leg 88. In the illustrated embodiment, leg 88 includes three apertures 92. It should be understood, however, that the number of apertures 92 and fasteners 94 used to couple leg 88 to bearing cup 76 may vary. Fasteners 94 comprise pins in one constructed embodiment. It should be understood, however, that other fasteners such as dowels, screws, rivets, or bolts may alternatively be used. Member 40 and bearing assembly 36 may be rotated within openings 52, 54 of carrier 12 using a tool that grasps one or more fasteners 94. Alternatively, leg 88 may define additional apertures 96 configured to receive a spanning tool used to rotate member 40 and bearing assembly 36. Apertures 96 may be equally angularly spaced about leg 88 and each of apertures 96 may be located midway between a pair of apertures 92, angularly equidistant from each aperture 92 of the pair.

[0028] Leg 90 extends axially and is perpendicular to leg 88, extending away from cup 76. Upon alignment of bearing assembly 36 within differential 10, leg 90 may be deformed by applying a radial force in a radially outward direction on the radially inner side of leg 90 at one or more locations. Referring to Figure 4, in this manner one or more portions 98 of leg 90 are urged radially out-

wardly and are inserted into slots 100 formed in carrier 12 thereby securing bearing assemblies against further movement.

[0029] Referring now to Figures 5 and 6, methods of assembling a differential in accordance with the present invention will be described. Each method may include the step 102 of providing a differential carrier 12 and a differential case 20 disposed within the differential carrier 12 wherein the differential carrier 12 and the differential case 20 are disposed about a first axis 56 and the differential carrier 12 has a plurality of threads 60 on a radially inner surface. Each method may further include the step 104 of inserting a bearing assembly 36 between the differential carrier 12 and the differential case 20 wherein the bearing assembly 36 includes a cup 76 having a plurality of threads 84 disposed on a radially outer surface and configured to engage the threads 60 on carrier 12. In accordance with one embodiment of the present invention illustrated in Figure 5, the method may conclude with the step 106 of rotating the bearing assembly 36 until a predetermined alignment position is reached.

[0030] In accordance with another embodiment of the present invention illustrated in Figure 6, the method may further include the step 108 of affixing a deformable member 40 to the cup 76 of the bearing assembly 36. Referring to Figures 1-3, member 40 may be affixed to cup 76 using one or more fasteners 94 extending through corresponding apertures 92, 110 in member 40 and cup 76, respectively. The use of member 40 allows bearing assembly 36 to be rotated in several ways. As described hereinabove, member 40 may include one or more apertures 96 configured to receive a tool. Accordingly, the step 106' of rotating assembly may include the substeps 112, 114 of inserting a tool through one or more of apertures 96 in member 40 and moving the tool until bearing assembly 36 reaches a predetermined alignment position. Alternatively, step 106' may include the substeps 116, 118 of grasping a fastener 94 coupling member 40 to cup 76 of bearing assembly 36 with a tool and moving the tool until bearing assembly 36 reaches a predetermined alignment position.

[0031] Referring again to Figure 6, the method may further include the steps 120, 122 of deforming at least a portion 98 of deformable member 40 after bearing assembly 36 has reached a predetermined alignment position and inserting the portion or portions 98 into a slot or slots 100 in differential carrier 12. Referring to Figure 5, one or more portions 98 of leg 90 of member 40 may be deformed and inserted into slots 100 by exerting a radially outward force on leg 90 (e.g., by using a punching tool).

[0032] A differential and method for assembling a differential in accordance with the present invention offer significant advantages. In particular, the bearing assemblies 36, 38 may be securely positioned in infinitely variable angular and axial positions. As a result, the bearing assemblies 36, 38 may be optimally aligned within dif-

ferential 10. The invention also reduces the cost and weight of differential 10 by eliminating the need for separate bearing adjusters.

[0033] While the invention has been shown and described with reference to one or more particular embodiments thereof, it will be understood by those of skill in the art that various changes and modifications can be made without departing from the spirit and scope of the invention.

## Claims

### 1. A differential (10), comprising:

a differential carrier (12) disposed about a first axis (56);  
a differential case (20) disposed within said differential carrier (12);  
a bearing assembly (36) disposed about said first axis (56) between said differential carrier (12) and said differential case (20), said bearing assembly (36) allowing said differential case (20) to rotate within said differential carrier (12)

wherein said differential carrier (12) includes a first plurality of threads (58) disposed on a radially inner surface and said bearing assembly (36) includes a cup (76) having a second plurality of threads (84) disposed on a radially outer surface configured to engage said first plurality of threads (58).

### 2. The differential (10) of claim 1, further comprising a deformable member (40) coupled to said cup (76) of said bearing assembly (36), at least a portion (98) of said deformable member (40) deformed and inserted into a slot (100) in said differential carrier (12) upon alignment of said bearing assembly (36) within said differential carrier (12).

### 3. A differential (10), comprising:

a differential carrier (12) disposed about a first axis (56);  
a differential case (20) disposed within said differential carrier (12);  
a bearing assembly (36) disposed about said first axis (56) and between said differential carrier (12) and said differential case (20), said bearing assembly (36) allowing said differential case (20) to rotate within said differential carrier (12); and,  
a deformable member (40) coupled to a cup (76) of said bearing assembly (36)

wherein at least a portion (98) of said deformable member (40) is deformed and inserted into a

slot (100) in said differential carrier (12) upon alignment of said bearing assembly (36) within said differential carrier (12).

### 4. The differential (10) of any one of claims 1 to 3, further comprising a plurality of fasteners (94) coupling said deformable member (40) to said cup (76) of said bearing assembly (36).

### 5. The differential (10) of claim 4 wherein said deformable member (40) is disposed about said first axis (56) and said fasteners (94) are equally angularly spaced about said deformable member (40).

### 6. The differential (10) of claim 4 or 5 wherein at least one of said plurality of fasteners (94) comprises a pin.

### 7. The differential (10) of claim 2 or 3 wherein said deformable member (40) is L-shaped in cross-section, having a first leg (88) coupled to said cup (76) of said bearing assembly (36) and a second leg (90) extending perpendicular to said first leg (88) and away from said cup (76) of said bearing assembly (36).

### 8. A method of assembling a differential (10), comprising the steps of:

providing (102) a differential carrier (12) and a differential case (20) disposed within said differential carrier (12), said differential carrier (12) and said differential case (20) disposed about a first axis (56) and said differential carrier (12) having a first plurality of threads (58) on a radially inner surface;  
inserting (104) a bearing assembly (36) between said differential carrier (12) and said differential case (20), said bearing assembly (36) including a cup (76) having a second plurality of threads (84) disposed on a radially outer surface and configured to engage said first plurality of threads (58); and,  
rotating (106, 106') said bearing assembly (36) until a predetermined alignment position is reached.

### 9. The method of claim 8, further comprising the steps of:

affixing (108) a deformable member (40) to said cup (76) of said bearing assembly (36);  
deforming (12) at least a portion (98) of said deformable member (40) after reaching said predetermined alignment position; and,  
inserting (122) said at least a portion (98) of said deformable member (40) into a slot (100) in said differential carrier (12).

10. The method of claim 9 wherein said rotating step (106') includes the substeps of:

inserting (112) a tool through an aperture (96)  
in said deformable member (40); and,  
moving (114) said tool until said bearing assembly (36) reaches said predetermined alignment position.

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11. The method of claim 9 wherein said rotating step (106') includes the substeps of:

grasping (116) a fastener (94) coupling said deformable member (40) to said cup (76) of said bearing assembly (36) with a tool; and,  
moving (118) said tool until said bearing assembly (36) reaches said predetermined alignment position.

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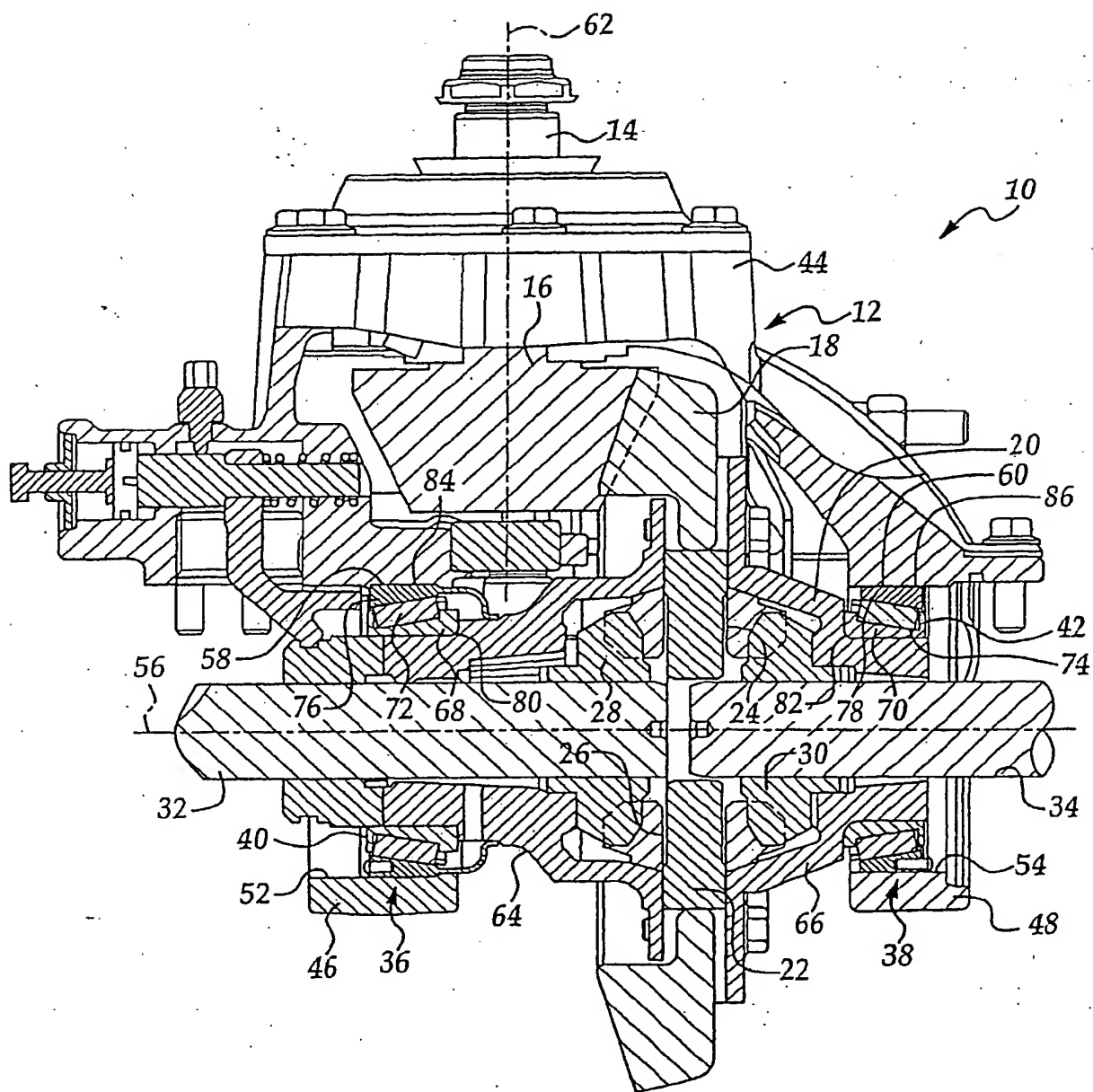


Figure 1

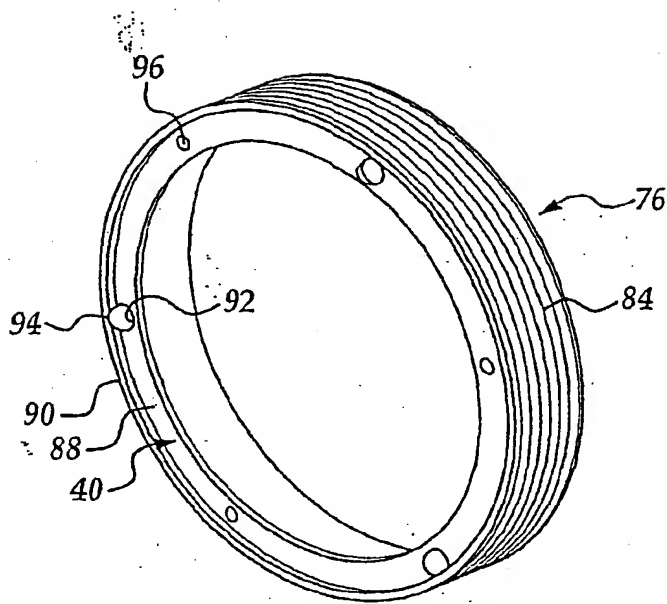


Figure 2

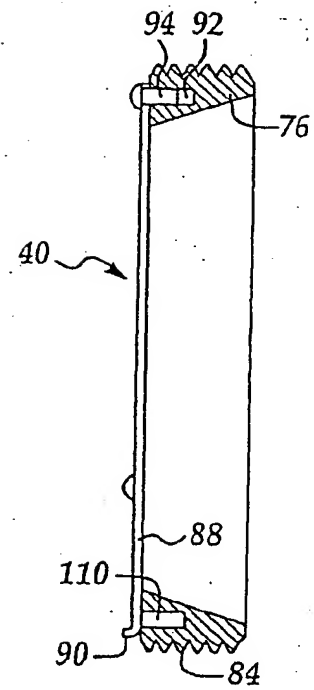


Figure 3

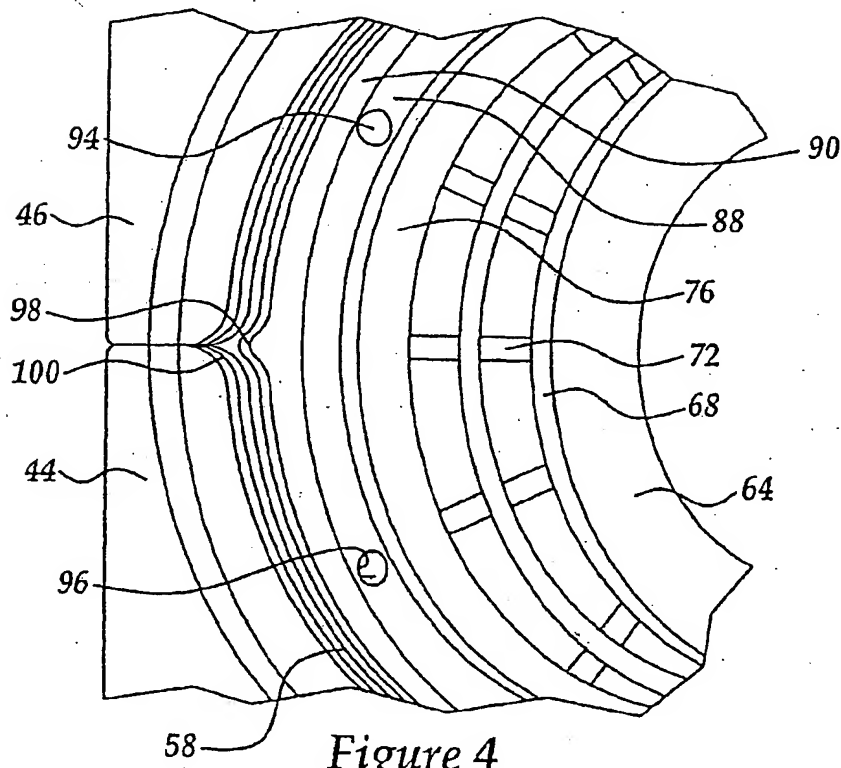
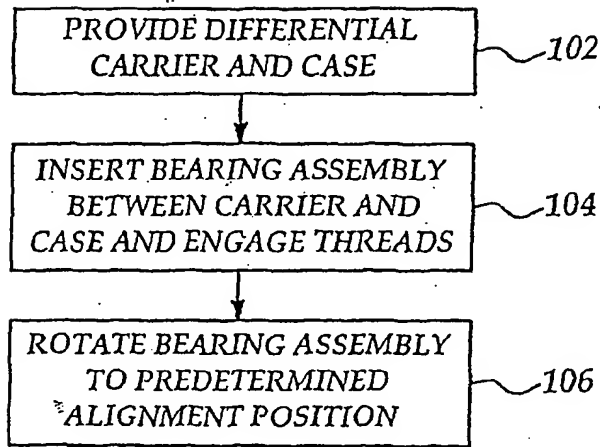
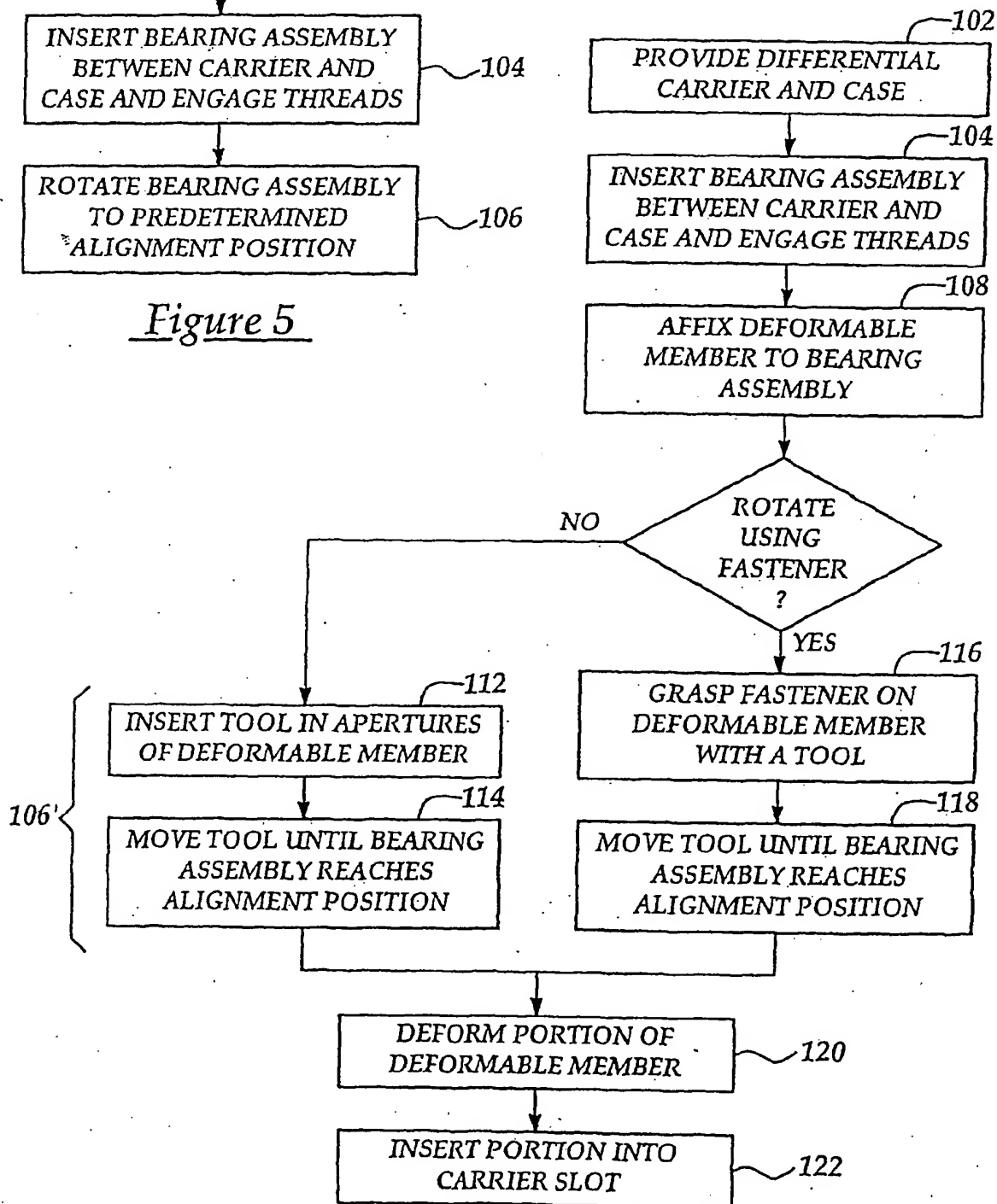


Figure 4



Figure 5Figure 6



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# EUROPEAN SEARCH REPORT

Application Number  
EP 03 25 3293

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The present search report has been drawn up for all claims			
Place of search <b>BERLIN</b>		Date of completion of the search <b>12 September 2003</b>	Examiner <b>Wilson, M</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>A : member of the same patent family, corresponding document</p>			

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# EUROPEAN SEARCH REPORT

Application Number  
EP 03 25 3293

DOCUMENTS CONSIDERED TO BE RELEVANT			
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<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document</p> <p>T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons ----- &amp;: member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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